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NATIONAL EUTROPHICATION SURVEY

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Report

on

Blackfish Lake

Crittenden and St. Francis Counties

Arkansas

EPA Region VI

Working Paper No. 481

With the cooperation of the

Arkansas Department of Pollution

Control and Ecology

and the

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January, 1977

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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CRITTENDEN AND ST. FRANCIS COUNTIES, ARKANSAS

EPA REGION VI

by

National Eutrophication Survey

Water and Land Monitoring Branch
Monitoring Applications Laboratory
Environmental Monitoring & Support Laboratory
Las Vegas, Nevada

and

Eutrophication Survey Branch
Corvallis Environmental Research Laboratory
Corvallis, Oregon

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OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY

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CONTENTS

	Page
Foreword	ii
List of Arkansas Study Lakes	iv
Lake and Drainage Area Map	v
Sections	
I. Conclusions	1
II. Lake and Drainage Basin Characteristics	4
III. Lake Water Quality Summary	6
IV. Nutrient Loadings	11
V. Literature Reviewed	15
VI. Appendices	16

FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point source discharge reduction and nonpoint source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by the U.S. Environmental Protection Agency and to augment plans implementation by the states.

ACKNOWLEDGMENTS

The staff of the National Eutrophication Survey (Office of Research and Development, U.S. Environmental Protection Agency) expresses sincere appreciation to the Arkansas Department of Pollution Control and Ecology for professional involvement, to the Arkansas National Guard for conducting the tributary sampling phase of the Survey, and to those Arkansas wastewater treatment plant operators who provided effluent samples and flow data.

The staff of the Water Division of the Arkansas Department of Pollution Control and Ecology provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports and provided critiques most useful in the preparation of this Working Paper series.

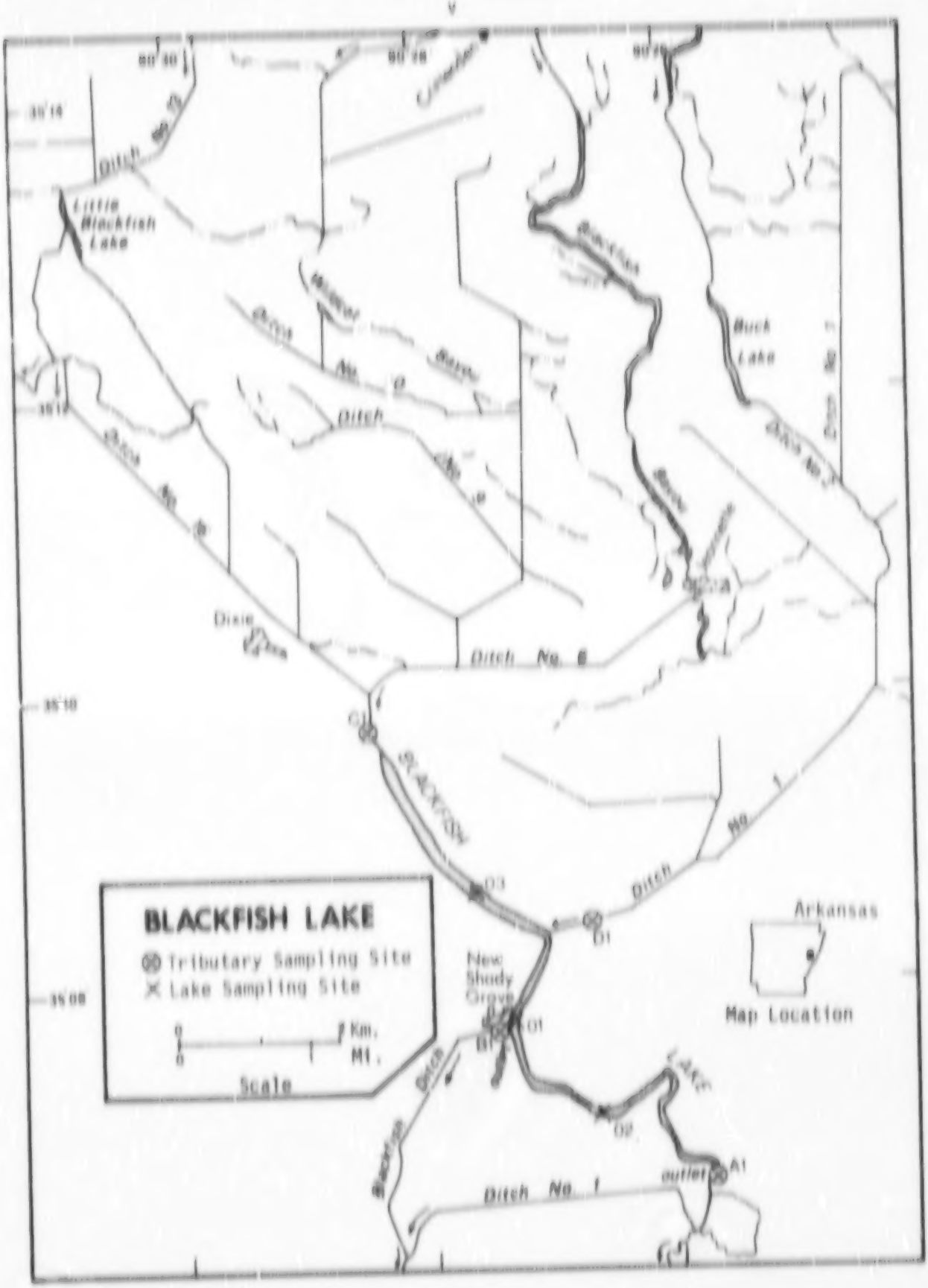
Major General Thomas C. Armstrong, the Adjutant General of Arkansas, and Project Officer Colonel Lavaun M. James, who directed the volunteer efforts of the Arkansas National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF ARKANSAS

LAKE NAME	COUNTY
Beaver	Benton, Carroll, Washington
Blackfish	Crittenden, St. Francis
Blue Mountain	Logan, Yell
Bull Shoals	Baxter, Boone, Marion (Taney, Ozark in MO)
Catherine	Garland, Hot Spring
Chicot	Chicot
DeGray	Clark, Hot Spring
Erling	Lafayette
Grand	Chicot
Greer's Ferry	Van Buren, Cleburne
Hamilton	Garland
Millwood	Hempstead, Howard, Little River, Sevier
Nimrod	Perry, Yell
Norfork	Baxter, Fulton (Ozark in MO)
Ouachita	Garland, Montgomery
Table Rock	Boone, Carroll (Barry, Taney in MO)


BLACKFISH LAKE
Tributary Sampling Site
Lake Sampling Site
Km.
Mi.
Scale
Arkansas
Map Location
Little Blackfish Lake
Buck Lake
Ditch No. 8
Ditch No. 1
Dixie
New Shady Grove
outlet
O1
O2
O3
A1
B1
C1

REPORT ON BLACKFISH LAKE, ARKANSAS

STORET NO. 0502

I. CONCLUSIONS

A. Trophic Condition:*

Based upon field observations and survey data, Blackfish Lake is considered hypereutrophic. Chlorophyll a values ranged from a low of 1.9 µg/l in the spring to a high of 70.1 µg/l in the fall with a mean of 19.8 µg/l. The mean Secchi disc transparency was only 9.8 cm (3.9 inches). Potentials for primary production as measured by algal assay control yields were extremely high. Of the 16 Arkansas lakes sampled in 1974, none had higher median total phosphorus, dissolved orthophosphorus, or inorganic nitrogen levels than Blackfish Lake.

Survey limnologists reported large amounts of floating debris and oil scum over the water surface. Emergent trees and branches were observed throughout most of the lake.

B. Rate-Limiting Nutrient:

Algal assay results indicate that Blackfish Lake is limited by available nitrogen. Spikes with nitrogen or nitrogen and phosphorus simultaneously resulted in increased

*See Appendix E

assay yields. The addition of phosphorus alone did not produce a growth response. The ratios of total available nitrogen to orthophosphorus (N/P) in the lake data suggest near-colimitation in the spring, nitrogen limitation in the summer, and phosphorus limitation in the fall.

C. Nutrient Controllability:

1. Point sources -

There are no known point sources impacting Blackfish Lake. The present phosphorus loading of 69.22 g/m^2/yr is 40 times that proposed by Vollenweider (1975) as eutrophic for a lake of such volume and retention time. Although Vollenweider's model may not apply to water bodies with short hydraulic retention times (eight days for Blackfish Lake) the loading is excessively high; regardless of the applicability of the model, it is certain that the trophic condition of Blackfish Lake will continue to deteriorate if the present loading rate is maintained.

2. Nonpoint sources -

Nonpoint sources contributed all the loading reaching Blackfish Lake. Measured tributaries contributed 99.0% of the total phosphorus load. Tributary C-1 (Unnamed Stream) contributed 84.8%, while ungaged tributaries contributed 1.0% of the total load.

The nonpoint phosphorus and nitrogen exports for the two tributaries to Blackfish Lake (Section IV-D) are extremely

high. These tributaries drain a vast agricultural watershed and are the result of a long array of interconnecting ditches and streams. Further investigation is necessary to determine the effects of this agricultural runoff into the lake and of any unknown sources contributing loading before recommendations for lake improvement can be proposed.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

Lake and drainage basin characteristics are itemized below. Lake morphometry values were provided by the Arkansas Department of Pollution Control and Ecology. Tributary flow data were provided by the Arkansas District Office of the U.S. Geological Survey (USGS). Outlet drainage area includes the lake surface area. Mean hydraulic retention time was obtained by dividing the lake volume by the mean flow of the outlet. Precipitation values are estimated by methods as outlined in National Eutrophication Survey (NES) Working Paper No. 175. A table of metric/English conversions is included as Appendix A.

A. Lake Morphometry:

1. Surface area: 1.62 km^2.
2. Mean depth: 1.8 meters.
3. Maximum depth: 6.7 meters.
4. Volume: 2.964 x 10^6 m^3.
5. Mean hydraulic retention time: 8 days.

B. Tributary and Outlet:
(See Appendix B for flow data)

1. Tributaries -

Name	Drainage area(km^2)	Mean flow (m^3/sec)
C-1 Unnamed Stream	247.3	3.65
D-1 Ditch #1	37.0	0.54
Minor tributaries and immediate drainage -	2.8	0.06
totals	287.1	4.25
2. Outlet - B-1 Blackfish Ditch	288.8	4.25

C. Precipitation:

1. Year of sampling: ?
2. Mean annual: ?

III. LAKE WATER QUALITY SUMMARY

Blackfish Lake was sampled three times during the open-water season of 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from three stations on the lake (Station 03 was sampled only twice) and from one or more depths at each station (see map, page v). During each visit, depth-integrated samples were collected from each station for chlorophyll *a* analysis and phytoplankton identification and enumeration. During the first visit, 18.9-liter depth-integrated samples were composited for algal assays. Maximum depths sampled were 1.5 meters at Station 01, 1.5 meters at Station 02, and the surface at Station 03. For a more detailed explanation of NES methods, see NES Working Paper No. 175.

The results obtained are presented in full in Appendix C and are summarized in III-A for waters at the surface and at the maximum depth for each site. Results of the phytoplankton counts and chlorophyll *a* determinations are included in III-B. Results of the limiting nutrient study are presented in III-C.

B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
03/26/74	1. Euglena	116
	2. Chroomonas	93
	3. Nitzschia	93
	4. Pharmidium	46
	5. Gyrosigma	23
	Other genera	117
	Total	488
06/04/74	1. Cryptomonas	475
	2. Flagellates	238
	3. Trachelomonas	238
	4. Euglena	59
	5. Lepocinclis	60
	Other genera	59
	Total	1,129
10/16/74	1. Nitzschia	1,767
	2. Cryptomonas	1,556
	3. Chlamydomonas	1,346
	4. Euglena	1,136
	5. Dactylococcopsis	1,093
	Other genera	4,627
	Total	11,525

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
03/26/74	01	1.4
	02	2.8
	03	8.8
06/04/74	01	11.3
	02	6.6
	03	13.5
10/16/74	01	70.1
	02	43.2
	03	****

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

a. 03/26/74

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum Yield (mg/l-dry wt.)
Control	0.175	0.917	28.4
0.05 P	0.225	0.917	25.8
0.05 P + 1.0 N	0.225	1.917	53.7
1.00 N	0.175	1.917	51.5

b. 10/16/74

Spike(mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum Yield (mg/l-dry wt.)
Control	0.062	0.386	11.9
0.05 P	0.112	0.386	12.9
0.05 P + 1.0 N	0.112	1.386	32.2
1.00 N	0.062	1.386	19.3

F. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that Blackfish lake had a high potential for primary productivity during the spring and fall sampling periods. The assay samples were nitrogen limited at those times as indicated by the increased yield of the test alga in response to an addition of inorganic nitrogen. Spikes with phosphorus and nitrogen simultaneously resulted in a maximum yield. Spikes with phosphorus alone did not produce a response significantly beyond the control yield.

The mean N/P ratio in the spring lake data was 14/1, suggesting near colimitation by the two nutrients. An N/P ratio of 14/1 or greater generally reflects phosphorus limitation. The N/P ratio for the summer was 6/1, indicating nitrogen limitation, and 10/1 for the fall, indicating phosphorus limitation.

IV. NUTRIENT LOADINGS
(See Appendix D for data)

For the determination of nutrient loadings, the Arkansas National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page V), except for the high runoff months of March and April when two samples were collected. Sampling was begun in June 1974, and was completed in May 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Arkansas District Office of the USGS for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a USGS computer program for calculating stream loadings. Nutrient loads indicated for tributaries are those measured minus known point source loads, if any.

Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of USGS) were estimated by using the mean annual nutrient loads, in $kg/km^2/yr$, in Unnamed Stream and Ditch #1, at Stations C-1 and D-1, and multiplying the means by the ZZ area in km^2.

A. Waste Sources:

1. Known municipal - None
2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Sources	kg P/yr	% of total
a. Tributaries (nonpoint load) -		
C-1 Unnamed Stream	95,065	84.8
D-1 Ditch #1	15,895	14.2
b. Minor tributaries and immediate drainage (nonpoint load) -	1,140	1.0
c. Known municipal STP's - None		
d. Septic tanks* -	5	<0.1
e. Known industrial - None		
f. Direct precipitation** -	30	<0.1
Totals	112,135	100.0
2. Outlet - B-1 Blackfish Ditch	92,130	
3. Net annual P accumulation -	20,005	

*Estimate based on 26 lakeside residences.
**Estimated (see NES Working Paper No. 175).

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (nonpoint load) -		
C-1 Unnamed Stream	340,320	87.1
B-1 Ditch #1	44,930	11.5
b. Minor tributaries and immediate drainage (nonpoint load) -	3,625	0.9
c. Known municipal STP's - None		
d. Septic tanks* -	275	0.1
e. Known industrial - None		
f. Direct precipitation** -	1,750	0.4
Totals	390,900	100.0
2. Outlet - B-1 Blackfish Ditch	303,920	
3. Net annual N accumulation -	86,980	

*Estimate based on 26 lakeside residences.
**Estimated (see NES Working Paper No. 175).

d. Mean Annual Nonpoint Nutrient Export by Subdrainage Area:

Tributary	kg P/km^2/yr	kg N/km^2/yr
Unnamed Stream	304	1,370
Ditch #1	430	1,214

e. Yearly Loadings:

In the following table, the existing phosphorus annual loading is compared to the relationship proposed by Vollenweider (1975). Essentially, his eutrophic loading is that at which the receiving waters would become eutrophic or remain eutrophic; his oligotrophic loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between eutrophic and oligotrophic.

Note that Vollenweider's model may not apply to lakes with short hydraulic retention times or in which light penetration is severely restricted by high concentrations of suspended solids in the surface waters.

	Total Yearly Phosphorus Loading (g/m^2/yr)
Estimated loading for Blackfish Lake	69.22
Vollenweider's eutrophic loading	1.80
Vollenweider's oligotrophic loading	0.90

V. LITERATURE REVIEWED

U.S. Environmental Protection Agency. 1975. National Eutrophication Survey Methods 1973-1976. Working Paper No. 175 National Environmental Research Center, Las Vegas, Nevada, and Pacific Northwest Environmental Research Laboratory, Corvallis, Oregon.

Vollenweider, R. A. 1975. Input-Output Models With Special Reference to the Phosphorus Loading Concept in Limnology. Schweiz. Z. Hydrol. 37:53-84.

VI. APPENDICES

APPENDIX A
CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX B

TRIBUTARY FLOW DATA

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APPENDIX C

PHYSICAL AND CHEMICAL DATA

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APPENDIX D

TRIBUTARY DATA

APPENDIX E

PARAMETRIC RANKINGS OF LAKES SAMPLED BY NES IN 1974

STATE OF ARKANSAS